Arctic Ice Algal Bio-Optics & Sea Ice Sediments

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LONG-TERM GOALS

The goals of this research are to improve our understanding of bio-optical variability, primary productivity, and the influence biogenic and nonbiogenic materials on heat flux in polar marine ecosystems. The data are being used in radiative transfer, thermo-optical, bio-optical productivity models.

OBJECTIVES

The main scientific objective is to understand the influence of ice algae and other inclusions on the apparent and inherent optical properties of sea ice systems. Quantitative relationships between optical, physical, biogeochemical and biological variability are being sought. The influence of biogenic and nonbiogenic materials on the heat budget of sea ice is being explored.

APPROACH

Basic methodology has been described in detail previously. Stratified in situ spectral transmission measurements were made throughout snow, sea ice, the bottom ice algal layer and subice. This approach maintains natural distributions of the snow, ice, water and inclusions, largely eliminating potential artifacts due to geometrical changes. Comparative in vivo observations were made by determining absorption spectra for particulate and dissolved materials in discrete samples from all layers. Sea ice data were obtained from Resolute, NWT (1993 & 1995) and Barrow, AK (1994). Absorption by sediments from sea ice and the benthos is also being examined from a number of locations; this effort is ongoing. Sediment samples have been collected at sites in the Canadian Archipelago and the Barents, Beaufort, Bering, Chukchi, Kara and Laptev Seas. Multilayered, spectral models are being used to examine the relative contribution of ice algae and other inclusions to light transmission and the heat budget.

WORK COMPLETED

Except for additional sediment samples collected by foreign colleagues, all experimental and ancillary field data have been tabulated and reduced to final form with graphical summaries. Results have been presented at ARI and AGU meetings and seminars. Collaborative efforts are in progress to compare, synthesize and model data. Two papers have been published, another was submitted for publication (10/97), and several others are in preparation.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **1998**	2. REPORT TYPE	3. DATES COVERED **00-00-1998 to 00-00-1998**
4. TITLE AND SUBTITLE **Arctic Ice Algal Bio-Optics & Sea Ice Sediments**		5a. CONTRACT NUMBER
		5b. GRANT NUMBER
		5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER
		5e. TASK NUMBER
		5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Old Dominion University,Center for Coastal Physical Oceanography,Norfolk,VA,23529**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM002252.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**7**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

RESULTS

Stratified transmission spectra provide local estimates of diffuse attenuation, but various models yield values varying by almost twofold if interfaces are considered. In situ attenuation spectra and in vivo absorption spectra for the ice algal layer show good spectral agreement (Fig. 1), and illustrate that algal absorption can dominate in this layer. Corrections for packaging effects are necessary to relate in vivo observations back to nature. Two waveband algorithms show promise for predicting algal biomass and snow depth from passive observations. Model results predict that ice algal absorption under a range of natural conditions usually accounts for <10% of the total absorption by snow and sea ice (Fig. 2). However, algal absorption may be on the order of 25-50% in refrozen leads with thin ice and little or no snow. Ice algae may retard spring ice accretion and accelerate ablation. Sediment concentrations on sea ice vary tremendously in abundance and spatially over many scales. Absorption by sediments is high but variable with a maximum in the UV (Fig. 3). No strong relationships have been discovered between spectrally averaged absorption and total suspended material, organic, inorganic or carbonate content, grain size classes or other ancillary data. Sediments are typically found in thin layers or discrete packets, and either form has a large effect on the absorption and transmission of light. Localized high absorption by sediments or biogenic materials can create pits in the ice.

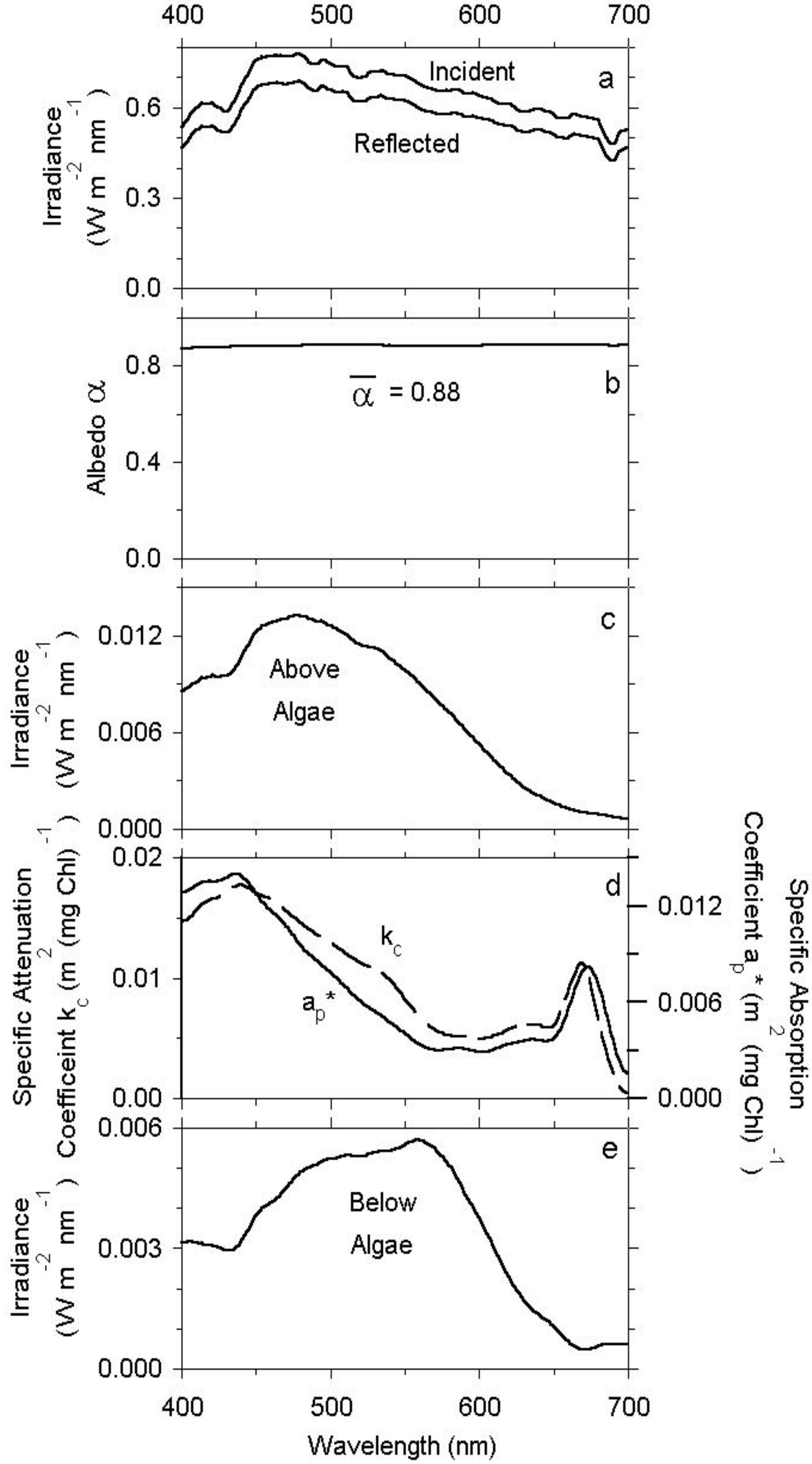

Figure 1. Irradiance and attenuation or absorption spectra at several levels in sea ice. Incident and reflected irradiance (a), albedo (b), transmitted irradiance above the ice algal layer (c), chorophyll specific attenuation and absorption (d, note different scales), and transmitted irradiance below the ice algal layer (e).

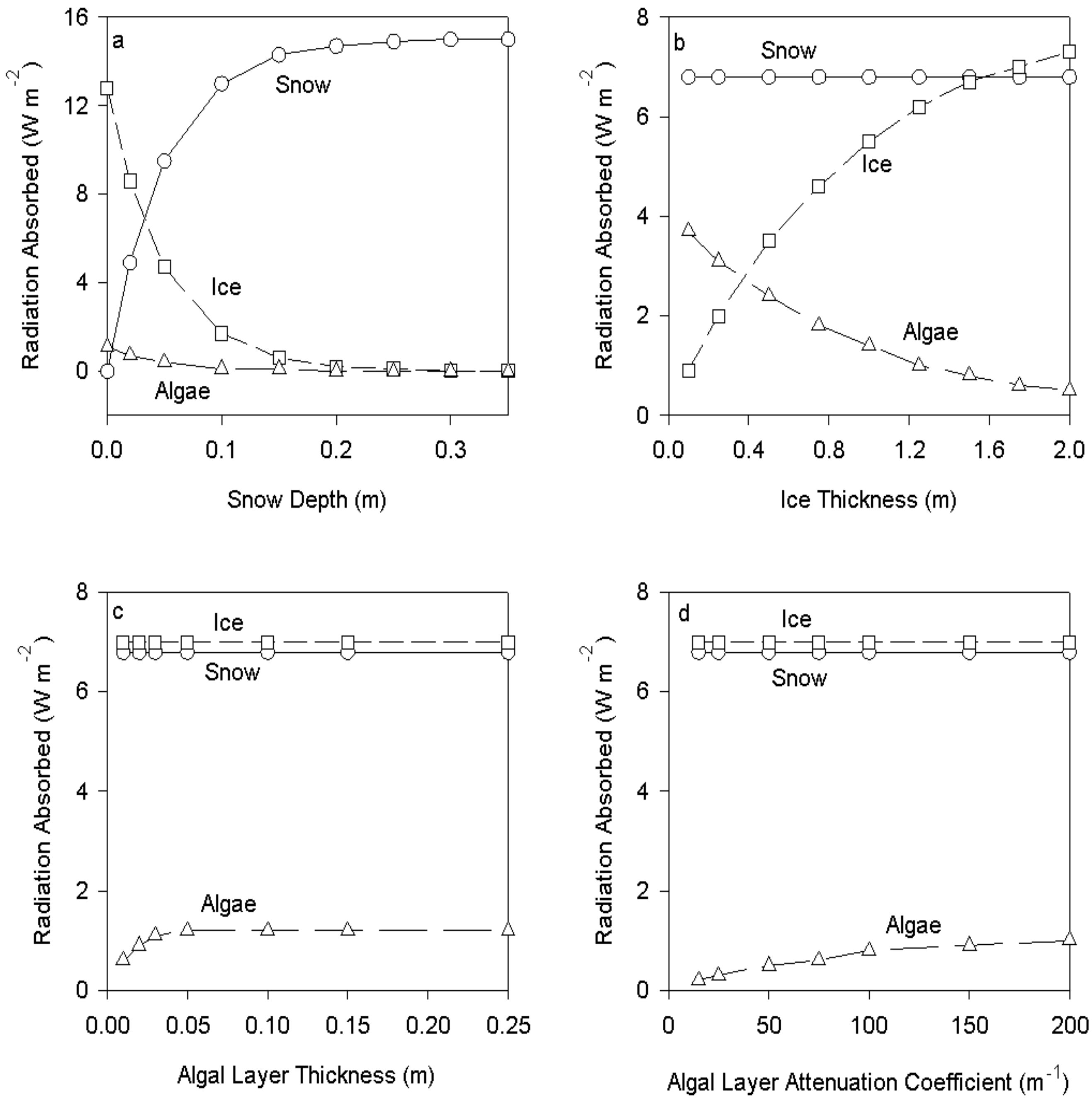

Figure 2. Absorption of radiation by snow, sea ice and bottom ice algae for a range of environmental conditions. Variable snow cover (a) on a 175 cm ice sheet, variable ice thickness (b) with 3 cm of snow. Snow and ice are held constant at 3 and 175 cm, respectively, when the algal layer thickness (c) or attenuation coefficient (d) are varied.

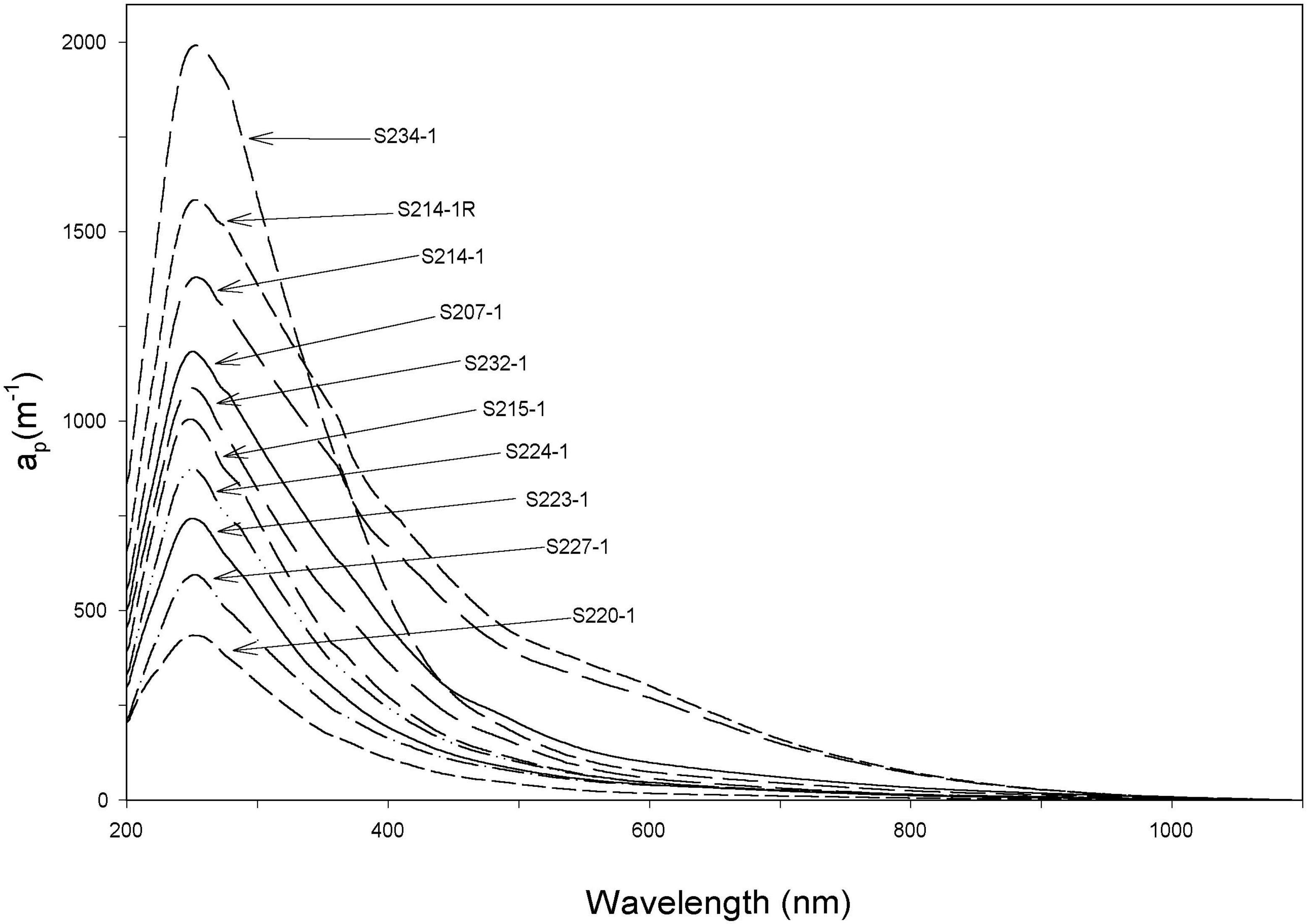

Figure 3. Sea ice sediment absorption spectra for samples scattered around the Arctic.

IMPACTS/APPLICATIONS

Photosynthetic action and absorption spectra of ice algae and related absorption spectra for dissolved and particulate (biogenic and sedimentary) materials provide a benchmark for bio-optical modeling of sea ice systems.

TRANSITIONS

Data have been (or will be) published and made available to collaborators.

RELATED PROJECTS

Collaborations are ongoing with R. Maffione, C. Mobley, and several others on various aspects of sea ice and snow and bio-optics.

PUBLICATIONS

Cota, G.F., W.G. Harrison and P. Kepkay. 1998. Dissolved organic material in sea ice: Biogeochemical implications and bio-optical properties. J. Geophys. Res. (submitted 10/97).

Mobley, C.D., G.F. Cota, T.C. Grenfell, R.A. Maffione, W.S. Pegau and D.K. Perovich, 1998. Modeling light propagation in sea ice. TGARS 36(5) 1743-1749.

Perovich, D.K. et al. 1998. Field Observations of the electromagnetic properties of first-year sea ice. TGARS 36(5) 1705-1715.

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PI - Maffione, R.A., G.F. Cota and C.D. Mobley, A layered model of light transmission through first-year sea ice.

PI - Perovich, D.K., G.F. Cota and E. Reimnitz, The influence of sediments in sea ice on spectral albedos and absorption.

GRADUATE STUDENTS

none

PATENTS

none

PRESENTATIONS

none

SERVICE ON COMMITTEES/PANELS

SeaWiFS Science Team
SeaWiFS Bio-optical algorithm working group
ADEOS/OCTS Science Team
ADEOS II/GLI Science Team
Arctic Icebreaker Coordinating Committee

HONORS/AWARDS

none